

On the Sexual Maturity of the Sperm Whale
(*Physeter catodon*) found in the Adjacent
Waters of Japan (I).

BY
MASAHARU NISHIWAKI,
of the Whales Research Institute

AND
TAKASHI HIBIYA,
of the Laboratory of Fishery Zoology,
Faculty of Agriculture,
Tokyo University

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Introduction

Since 1948 the ecology of the whales found in the waters adjacent to Japan has been studied by a group of biologists of the Fisheries Agency, Japanese Government and of the Whales Research Institute. Such biological characters of the various whale species have been surveyed in this study as body length composition, body length at the sexual maturity, geographical distribution, migration, age and others.

While mature female whales can easily be distinguished from those

sexually immature by the presence of yellow bodies in their ovaries, whether a male whale is sexually mature or not can hardly be determined exactly without examining its testes histologically.

Mackintosh and Wheeler, however, correlated the results of their histological observations on the testes of the Antarctic blue and fin whales to the volumes of their testes, and concluded that the degree of the sexual maturity of these whales can be determined on basis of the volume of their testis (Mackintosh and Wheeler: 1929). Matthews applied an alike treatment to the sperm whales from the Southern hemisphere, and estimated their body length at the sexual maturity at 38 to 41 Eng. ft. (Matthews: 1938).

Aforesaid Japanese group has been measuring the volume and weight of testis of the whales as a tentative means of studying the body length of male whales at the sexual maturity. As far as the data hitherto collected by this group concern, both the ratio "testis volume / body length" and the ratio "testis weight / body length" show the same trend, and the latter ratio correlates better to the degree of sexual maturity than the former.

As an illustration, we shall quote the case of the Antarctic male blue whales which were caught by two Japanese whaling fleets during the three seasons 1946-47 through 1948-49. This case has been studied by the senior author of this paper (Nishiwaki: 1950).

In Figure 1 are plotted the weight of testis of each individual blue whale against the body length. Inspecting the distribution of the plots in the figure, one can segregate the sexually mature whales from the immature individuals with a considerable accuracy. The average weight of testis for the body length class increases with the body length, gradually for lower body length classes but rapidly for the body lengths 72 Eng. ft. and over. Consequently the curve depicting these averages is discontinuous at the point "72 Eng. ft. (body length)-5 kg. (weight of testis)." This seems to show that both the volume and weight of the testis increase rapidly as the result of the vigorous multiplication of testis contents. The formation of spermatozoa was actually observed in the histological samples of the testes of this stage. Based on these data and reasoning, it was concluded that 10 kg. is the average minimum weight of the pair of testes of the Antarctic male blue whales at the time of the sexual maturity, and that the average body length at that stage measures 75 ft. since the average weight of a pair of testes attains 10 kg. at this body length.

Sei and fin whales found in the waters adjacent to Japan have been

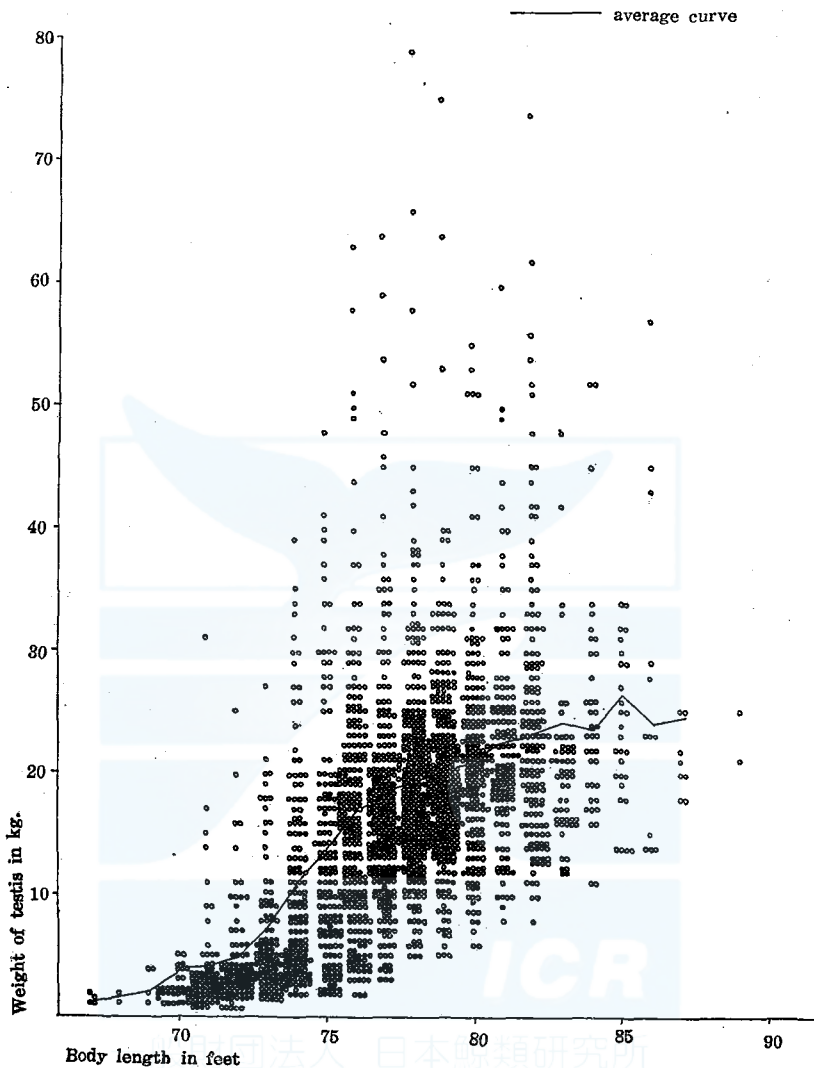


Fig. 1. Weight of testis and body length in Antarctic blue whales caught by Japanese fleets, 1946-47 through 1948-49 (from Nishiwaki: 1950)

treated in the same method as above. The results, though they are not yet conclusive on account of the scarcity of the data, are usable in estimating the sexual maturity of the males in rough.

As to sperm whales, however, the difference in the weight of testis between mature and immature groups is not so conspicuous as in the foregoing species, nor any discontinuous points have been detected on their "body length-testis weight average curve." As an illustration,

the relation between body length and weight of testis of the sperm whales caught in Figure 2. Original data were taken from Omura (Omura : 1950).

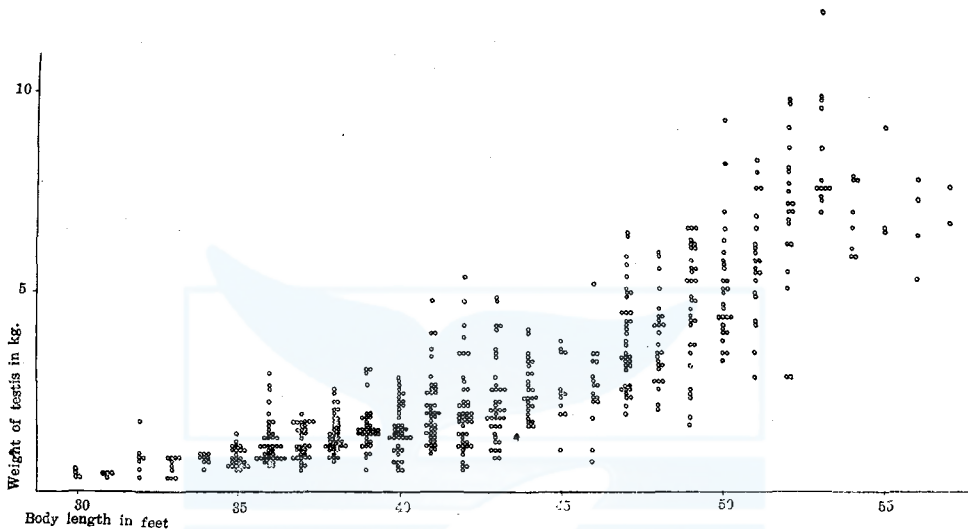


Fig. 2. Weight of testis and body length in sperm whales caught in the adjacent waters of Japan during 1948 and 1949 (from Omura : 1950)

This figure hardly suggests any standard that can be used for estimating the sexual maturity of these male sperm whales. Thence it was decided to investigate the testis of sperm whales histologically, and we have been in charge of that investigation.

The joint author, Takashi Hibiya, has been participating in this study in order to handle a mass of histological samples in a short period of time and to supply more specialized histological knowledges, ever since such assistance became necessary in 1951. Therefore, he did not take part in such phases of this study as planning and collection and fixing of the histological samples.

Chapter I.

Method of Investigation and the Materials

The materials used for this study are the sperm whales caught in the waters south-east off Hokkaido, Japan (Figure 3) during the period July 19-October 6, 1950. They consist of 90 males of the body lengths between 35 and 53 Eng. ft. and 80 females between 34 and 39 Eng. ft.

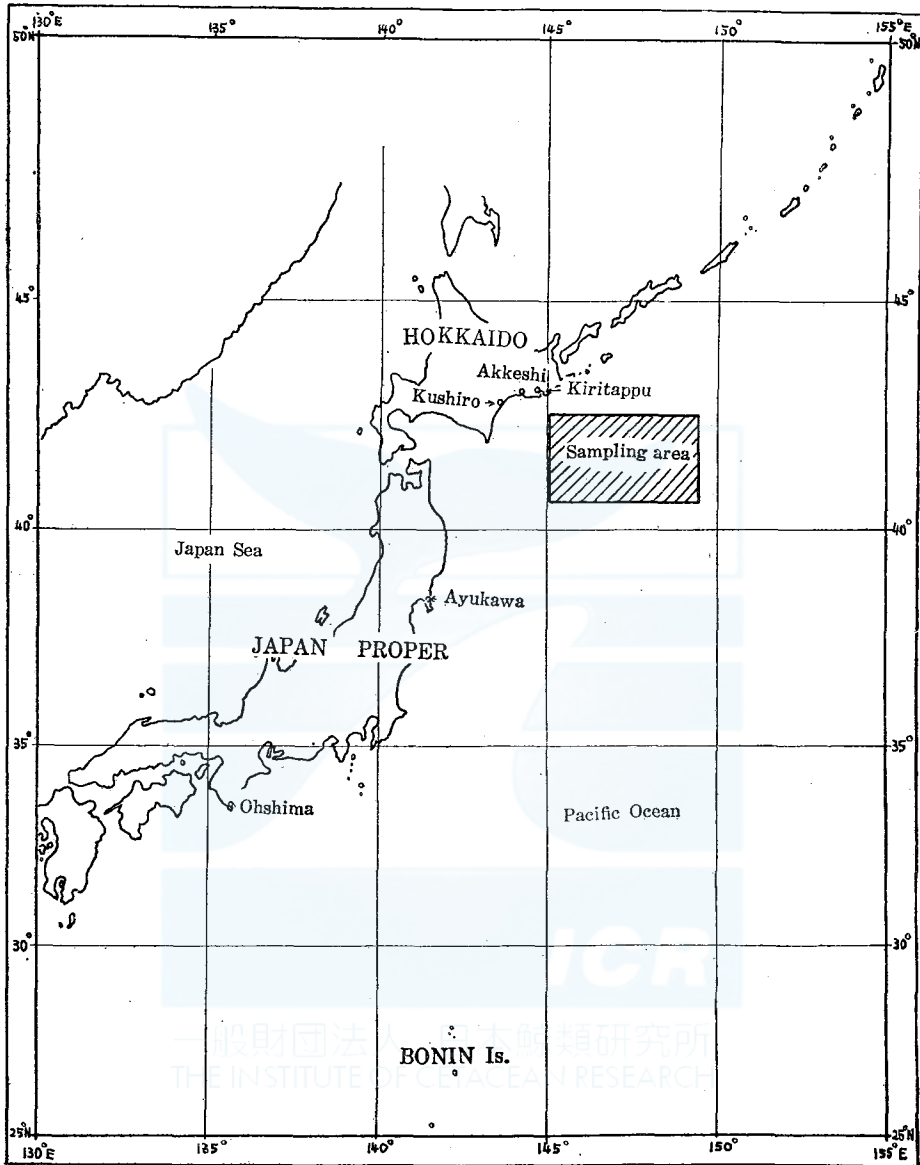


Fig. 3. Location of Sampling area

These whales were towed to and dissected at the land stations 14 to 24 hours after they were captured. When they were dissected, the measurements were made in the ordinary manner, their testes or ovaries were taken out, and the right and left testis were weighed separately. Thereafter, in the case of male, each small sample piece

of the right and left testis was cut off and was immediately fixed in the alcohol-formalin mixture. A few samples were fixed in formalin as the former solution was not available. The fixed sample pieces were cut into the sections 5 to 7 micron thick in the paraffin method, double-stained with haematoxylin-eosin, and subjected to the microscopic examination. In the case of female, yellow bodies (corpla lutea) were counted in the usual method.

We express our heartfelt thanks to the Japan Marine Products Co., Ltd., the Taiyo Fishing Co., Ltd. and the Kyokuyo Whaling Co., Ltd. for their immense cooperations in collecting the materials and data for this study. We are grateful also to Messer. Keijiro Maeda, Haruyuki Sakiura, Yoshio Teraoka, Setsuo Nishimoto and Shigeo Miyamoto, government inspectors from the Japanese Fisheries Agency, and to Mr. Kazuo Fujino, member of the Whales Research Institute who all directed the collection of the materials in the field. Our thanks are also due to the Japan Whaling Association to which we owe much of the research fund for this study.

Chapter II.

Sexual Maturity of the Male and its Relation with Body Length and Weight of Testis

Since the spermatogenesis generally takes place in the convoluted seminiferous tubules ("Tubuli seminiferi contorti") and not in the straight seminiferous tubules ("Tub. semini. recti") in mammals, we examined the former tubules closely and determined whether the spermatozoa were present or not.

All the male sperm whales that were dealt with in the present study measured more than 35 Eng. ft. in body length, and needless to say, none of their testes were found in such an immature stage where the spermatogonia, mingled by Sertoli's cells, are arranged on the inner wall of the convoluted seminiferous tubules in a simple manner. The earliest stage we observed was such where numbers of spermatocytes were observable. We met with a variety of more advanced stages, including the one at which spermatocytes were in division, the one where spermatids were already observable, or those where the development was further advanced. The last include the stage where spermatozoa are clearly seen. (See the photographs in the Appendix.)

The well developed spermatozoa of the sperm whale as we observed was of the shape typical to that of the mammal. Its head was pos-

Table 1.
Maturity of testis of the male sperm whale
at various body length

Body Length in English Feet	Number of Testes Examined			Percentage to Total	
	Total	+	-	+	-
35	4	4	0	100	0
36	26	21	5	82	18
37	28	24	4	86	14
38	26	24	2	92	8
39	12	11	1	92	8
40	16	15	1	94	6
41	14	13	1	100	0
42	8	8	0	100	0
43	6	6	0	100	0
44	12	12	0	100	0
45	16	16	0	100	0
46	4	4	0	100	0
47	0	0	0	0	0
48	0	0	0	0	0
49	0	0	0	0	0
50	4	4	0	100	0
51	2	2	0	100	0
52	0	0	0	0	0
53	2	2	0	100	0

+ : Spermatozoa were found in the histological sample.
- : Spermatozoa were not found in the histological sample.

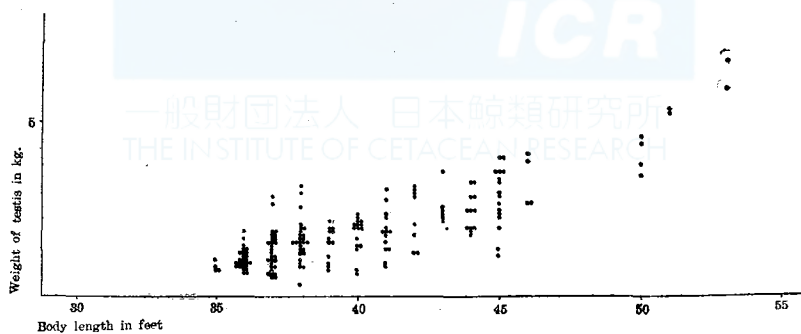


Fig. 4. Weight of testis and body length in the sperm whales caught in sampling area in 1950 and examined in this study.
○ Sexually immature whale
● Sexually mature whale

sessed of a distinct acrosome and was rather elongated. The middle piece, approximately as long as the head, followed the head and terminated in a long tail.

At first, all the section preparats of testes that were prepared in the aforesaid method were examined for the presence spermatozoa. The result is summarized for each body length class and is presented in Table 1 and Figure 4.

We had two examples of the body length of 35 Eng. ft., in the testes of both which the spermatozoa were detected. In each body length class from 36 to 40 Eng. ft. there were few individuals from which spermatozoa were not detected, and the percentage of such whales gradually decreased towards higher body length classes. As we shall discuss later, weights of the right and the left testis of an individual whale were not always equal: in general they were unequal rather than equal. In some individuals the spermatozoa were found from only one of their pair of testes, and not from the other. Such cases counted three in the body length class 36 Eng. ft., two in both of the 37 and 38 Eng. ft. classes and one in both of the 39 and 40 Eng. ft. classes. In two of these cases the spermatozoa were found only in the right testis; in the other seven cases they were detected only in the left testis. There were two individuals in all from the testes of which the spermatozoa were not found. One of them belonged to the 36 Eng. ft. class and the other to the 37 Eng. ft. class.

There was little room for confusion so far as the spermatozoa were observed distinctly in the section preparats. But, if they failed to be detected, all we could say was that spermatozoa were not present in that part of the testis we examined histologically; they might be present in some other part of the testis.

In the consequence it came to be necessary to investigate not only the presence or absence of spermatozoa in the convoluted seminiferous tubules, but also the conditions of various cells therein. In other words, we had to have informations as to the spermatocytes, the presence or absence of spermatids, the degree of abundance of spermatids if they were present, and the presence or absence of such spermatids that were undergoing the transformation into spermatozoa.

Investigating these aspects, we found that the two individuals, of 39 and 40 Eng. ft., from which we failed to detect any spermatozoa, had sexually developed to a considerable extent and were not to be called immature. That individual of 38 Eng. ft., from only the left of whose testes the spermatozoa were detected, is considered as an

abnormal individual, because the weights of its two testes differed from each other so conspicuously.

After all, it is proved by our data that the sperm whales, like many other animals, attain the sexual maturity not simultaenously at a definite body length, but individually over a certain range of body length. And it seem quite natural that they should do so. Since we can take an individual as being sexually mature if we find spermatozoa at least in one of its pair of testes, we have only to consider the body length frequency of those whales whose spermatozoa are not found in either of its testes, so far as we are concerned about the body length at the sexual maturity for practical purposes. Such individuals were not found in the body length classes 38 Eng. ft. and over, as we have described; in other words, 37 Eng. ft. was the upper range of the body length of such whales.

The result of our histological examination is summarized in Table 1 and Figure 4, where the right and left testis of each whale are counted individually, and those testis from which no spermatozoa were found are classified into the (minus) or immature group, irrespective of the feature of development of the testis tissue. Being based on these data, we can conclude that the body length of the sperm whales found in the adjacent waters of Japan at the sexual maturity is likely to be 35 to 37 Eng. ft., instead of 38 to 41 Eng. ft. or 42 Eng. ft. as was claimed by Matthews or Matsuura and Maeda (Matthews: 1938, and Matsuura and Maeda:1942).

Then we shall refer to the relation between the sexual maturity and the weight of testis of sperm whales. In 10 of the 90 individuals we examined the weights of the right and left testis were equal; in 35 of them the right testis was heavier than the left; in the other 45, the left was heavier than the right. Therefore, neither of the right and left testis showed any such tendency that one was always heavier than the other.

So far as our materials concern, those testis in which no spermatozoa were found always weighed less than 1.6 kg. But it did not follow that all the light testis lacked spermatozoa. We found spermatozoa in a testis that weighed only 0.6 kg. The heaviest testis that we met on the course of this study was the right testis of a male of 53 Eng. ft. in body length, and weighed 6.8 kg.

Chapter III.

Sexual Maturity of the Female

As was described in Chapter I, we distinguished mature female sperm whales from immature individuals on basis of the presence of the yellow bodies (corpora lutea) in the ovaries of the mature individuals, as in the case of the baleen whales.

Figure 5, which was cited from Omura (Omura: 1950,), shows the relation between the body length and the number of yellow bodies of the female sperm whales caught in the Japanese waters in 1948 and 1949. In those years the body length limit of 30 Eng. ft. was applied to the castal operations. Three immature individuals (about 2% to

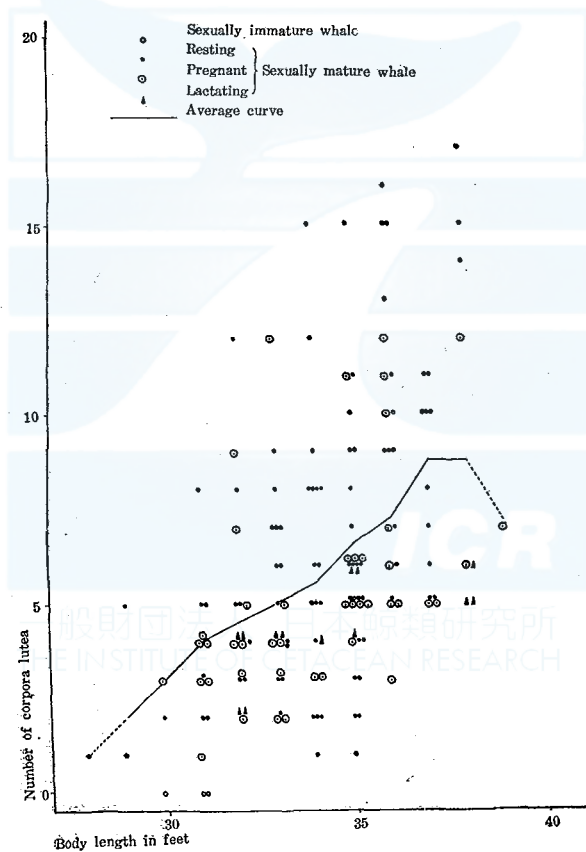


Fig. 5. Number of corpora lutea and body length in sperm whales caught in the adjacent waters of Japan in 1948 and 1949 (from Omura: 1950)

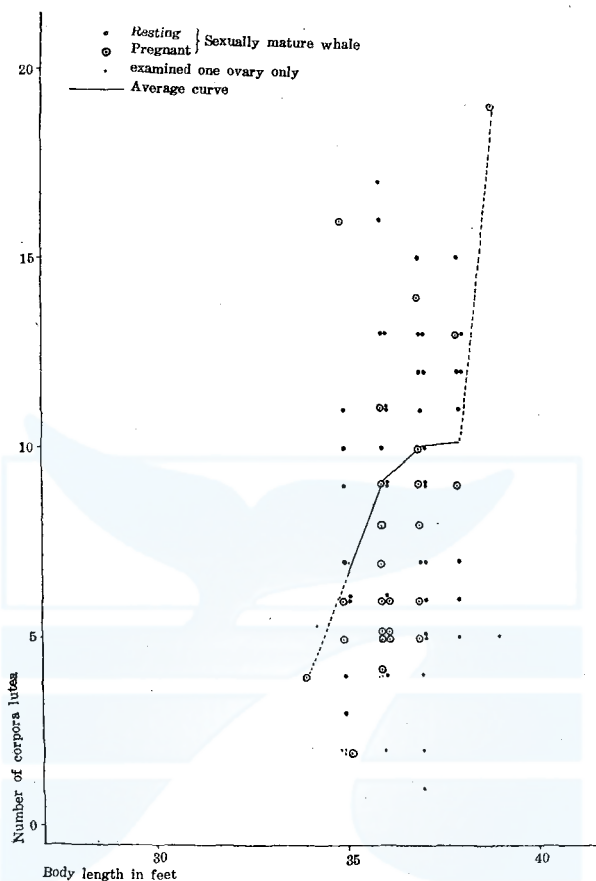


Fig. 6. Number of corpora lutea and body length in sperm whales caught in sampling area in 1950 and examined in this study.

the total) are included in Omura's data quoted here; one of them measured 30 Eng. ft. in body length and the other two 31 Eng. ft.

In 1950 the body length limit was raised to 35 Eng. ft. As the result, a few individuals below 34 Eng. ft. were caught during that year. And one of them were deat with in our study. And no immature individual was caught in 1950 as shown in Figure 6. The numbers of the individuals we examined are shown by body length classes in Figure 7. These figures show that the average number of yellow bodies was 6 to 7 at the body length of 35 Eng. ft. Excluding those whales one of whose pair of ovaries was not examined, eight or 5.6% of the examined whales of the body lengths of 35 Eng. ft. and over were possessed of three or less yellow bodies. The average numbers of yellow

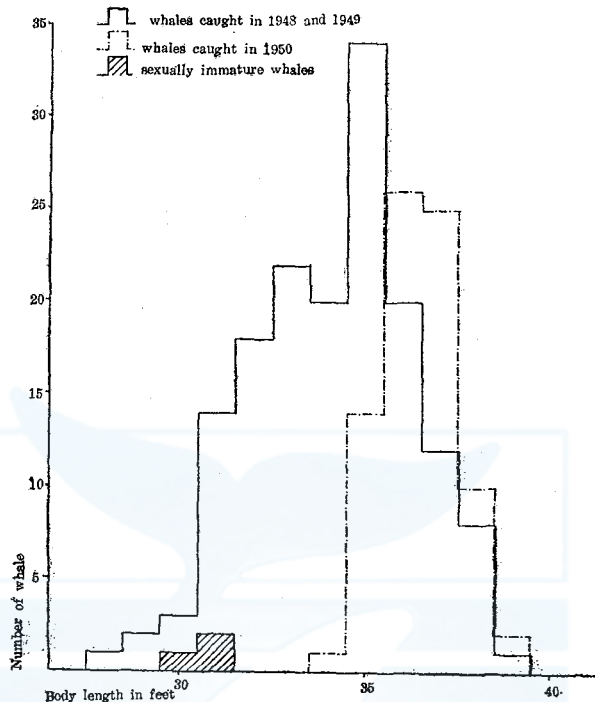


Fig. 7. Length distribution of examined female sperm whales.

bodies at various body lengths are shown by the curves in the figures.

Though our data on the immature or smaller individuals are too short in order to estimate the body length of the female sperm whale at the time of their sexual maturity, we are rather of opinion that Matthew's estimate is almost correct. It is probable that the body length at the sexual maturity of the female is subject to smaller personal errors of estimation than that of the male, because the former can be estimated more easily and with a more distinct result than the latter.

Chapter IV.

Conclusion

Being based on the foregoing evidences, we estimate that the male sperm whales found in the adjacent waters of Japan mature at the body length from 35 to 37 Eng. ft.

As to the body length at the sexual maturity of the female, we are not able to make any definite estimate at present, because the

data on the immature individuals are short. But we think that the estimates previously made by various authors are almost correct. And all the females of the body length of 35 Eng. ft. and over (the body length limit defined by the existing International Whaling Convention) were considered as being sexually mature. It was only 5.6% of them that were possessed of three or less yellow bodies. In other words, the great majority of the females over 35 Eng. ft. had bred several times.

Our conclusion in the foregoing lines is to be verified by the studies in future. We are not contented with the number of our samples. And we shall have to study how the present conclusion applies to other seasons or to such other grounds as the Bonin waters, the waters around Oshima and off Tohoku and others. These subjects will be discussed in a series of papers that will appear under the same title as this.

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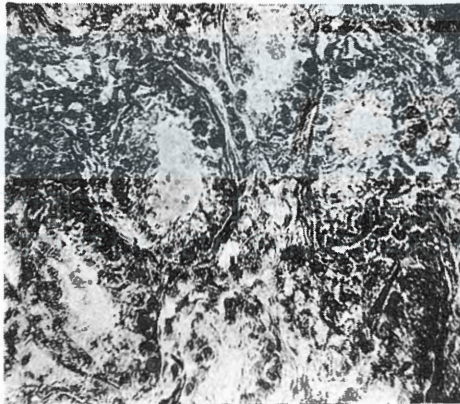
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Appendix
Microphotographs of the Sections of Testis Tissues
of the Sperm Whale

PLATE I.



A. A section of inactive testis tissue. The youngest stage among all the samples examined. (No. N. 375. Body length: 36 Eng. ft.) ($\times 250$)

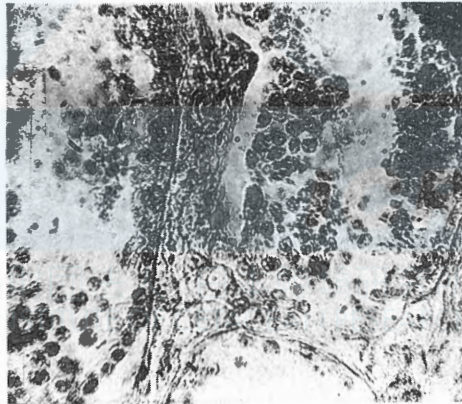


B. Spermatocytes are shown. This testis is classified in the — (minus) group in Table 1 and Figure 4. (No. N. 327. Body length: 38 Eng. ft.) ($\times 260$).

PLATE II.

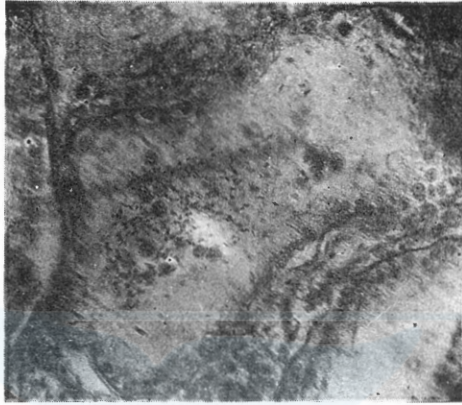


A. Spermatids before undergoing metamorphosis are shown. Well developed spermatozoa are found in other parts of this section than presented here. (No. H. 358. Body length: 46 Eng. ft.) ($\times 260$).

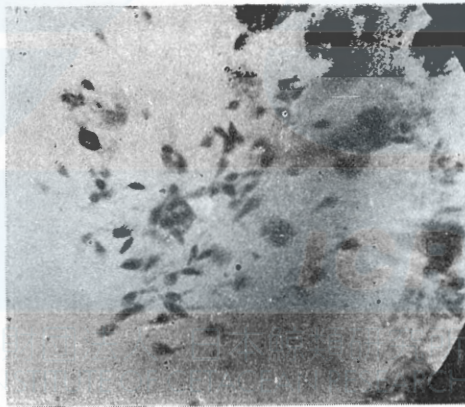


B. Various stages of the metamorphosis of spermatids are shown. (No. H. 276. Body length: 41 Eng. ft.) ($\times 260$).

PLATE III.



A. Well developed spermatozoa are shown. (No. K. 83.
Body length : 37 Eng. ft.) ($\times 200$)



B. Spermatozoa. (No. K. 83. Body length : 37 Eng. ft.)
($\times 950$)